Use of Brick Kiln Dust Waste in Paver Block to Improve its Mechanical Properties

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Abstract— Concrete paver blocks are special pre-cast pieces of concrete blocks of non-interlocking or interlocking types, commonly used in exterior landscaping pavement applications. Properly designed and constructed paver blocks give excellent performance at locations where conventional pavement systems have lower service life due to a number of environmental, geological constraints. But with the use of high-performance concrete they can be designed to sustain light, medium, heavy and very heavy traffic conditions under any constraints. The objective of the present work was to evaluate the performance of concrete modified with brick kiln dust for paver blocks for use in pavements and other application areas. As compressive strength, and water absorption are the most significant properties for concrete paver blocks the same have been studied for various concrete mixes with varying percentages of brick kiln dust. Brick kiln dust was used as partial replacement of cement in the study and six percentages 0%, 5%, 10%, 15%, 20%, 25% for dumbbell shape paver blocks. The mix with 15% replacement was found to give maximum compressive and maximum water absorption for all types of paver blocks.

Keywords— Paver block, Brick kiln dust, compressive strength, water absorption, Interlocking

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I. INTRODUCTION

The use of interlocking pavement blocks has a long history behind it. Remnants of interlocking pavement blocks roads built by Roman scan be still found today. However, the real popularity of concrete pavement blocks started when they began to be used in big way in Netherlands in the 1940s. The first interlocking concrete pavement blocks were shaped and sized just like bricks. In fact, since they were first used in Netherlands or Holland, they were called “Holland Stones”. In India, they are now finding an increasing number of applications, with demand being generated from both the realty and the infrastructure development sectors. Interlocking concrete block pavement (ICBP), as they are often referred to in technical parlance, are fast finding an increasing number of takers in India. While they may have made their entry into the Indian market about a decade ago, they have been in use for decades together in several other countries.

A. *ADVANTAGES*

- Mass production under factory conditions ensures availability of blocks having consistent quality and high dimensional accuracy.
- Good quality of blocks ensures durability of pavements, when constructed to specifications.
- ICBP does not require curing, and so can be opened for traffic immediately after construction.
- Construction of ICBP is labour intensive and requires less sophisticated equipment.
- Low maintenance cost and a high salvage value ensures low life cycle cost.

B. *LIMITATIONS*

- Poor surface riding quality.
- Speed of vehicle restricted to 60 kmph.
- Due to Low surface resistance skidding of vehicle.
- Breaking of paver blocks especially corner breaks.

II. MATERIALS AND METHODOLOGY

A. Material

i) Brick Kiln Dust (BKD): It is a waste material obtained from brick kiln industries. In INDIA, brick kiln industries are the third largest industry where the coal is used to baking the clay brick. Now day’s construction work is on large scale so demand of brick also increases so due to this brick kiln industries all over the world has also increased. So, such materials are used in filling low lying area and also in construction work it also used in mixture of cement concrete to fill the voids. As brick kiln dust contains mixture of ashes (coal+ wood) and dust particles (soil+ sand). In this experiment BKD collected from brick kiln bareta- patiala highway, bareta mandi, India is used. Physical properties of BKD are calculated

- Sieve Analysis: Sieve analysis is done by sieving the aggregates as per IS: 2386 (Part I) – 1963 to determine the particle size distribution of the material. In this Sieve size standardized by the IS code between 4.75 mm to 75microns is used. Observation of sieve analysis is shown in table I.

TABLE I SIEVE ANALYSIS OF BKD

S.N.	SIEVE SIZE	WEIGHT RETAINED W1 (grams)	% RETAINED IN EACH SIEVE W1/W*100	CUMULATIVE WEIGHT RETAINED (grams)	% PASSING (100-COL 4)
1	4.75	33.8	11.26667	11.26667	88.73333
2	2	32.1	10.7	21.96667	78.03333
3	1	37	12.33333	34.3	65.7
4	425	34.8	11.6	45.9	54.1
5	212	35.2	11.73333	57.63333	42.36667
6	125	46.5	15.5	73.13333	26.86667
7	75	35.5	11.83333	84.96667	15.03333
8	PAN	45.1	15.033	100	0
	Total	300			370.833

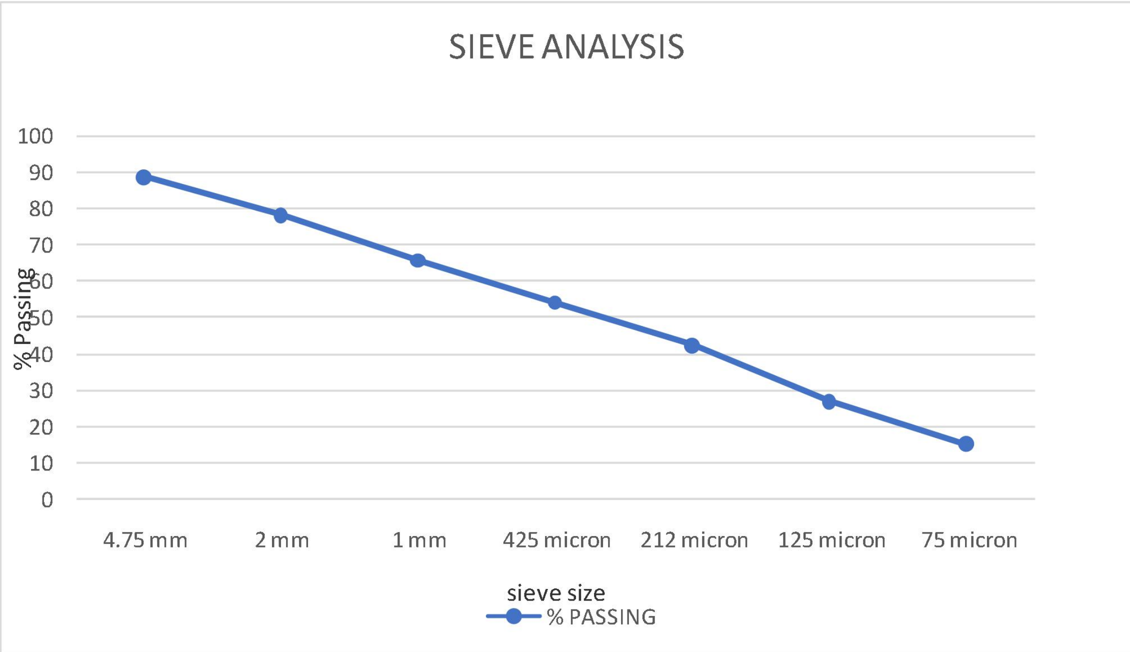

Figure 1 Sieve analysis

Fineness Modulus = (total % passing/ 100)
= 370.8333/100
= 3.708

- Specific Gravity Test: specific gravity of BKD fraction passing 4.75 mm I.S sieve is done by using density bottle. Observation take is in the table II

TABLE II SPECIFIC GRAVITY OF BKD

S. No.	Observation	
1	Weight of the sample in g	400
2	Weight of density bottle (W1 g)	590
3	Weight of density bottle + dry BKD (W2 g)	990
4	Weight of bottle + dry BKD + water (W3 g)	1622
5	Weight of bottle + water (W4 g)	1466

$$\textit{Specific gravity of soil} = \frac{\text{Density of water at 27 C}}{\text{Weight of water of equal volume}}$$

$$= \frac{(W_2 - W_1)}{(W_4 - W_1) - (W_3 - W_2)}$$

$$= \frac{(W_2 - W_1)}{(W_2 - W_1) - (W_3 - W_4)}$$

Specific Gravity = 2.35

ii) Cement: Various types of cement can be utilized for production of precast concrete paver block as per IS 15658: 2006. But in this experimental study the OPC 43 Grade cement has been utilized which confirming IS 8112: 1989.

iii) Fine aggregate: As per concerning IS 15658: 2006 Fine aggregates shall conform to the requirements of IS 383 both river/quarry sand and stone dust meeting the requirements can be used.

iv) Coarse aggregate: As per concerning IS 15658: 2006 coarse aggregate shall conform to the requirement of IS 383. For ensuring durability, the aggregate used for the manufacturing of paver blocks shall be sound and free from honeycombed particles in this experiment. In this experimental study nominal size of aggregate (12 mm) suggested for paver block is used.

v) Water: Used water is portable drinking water and free from organic solid materials as confirming to IS 456: 2000 having pH 7.5.

B. Mix Proportions

M35 grade of concrete is considered. Cement is replaced with Brick Kiln Dust in 5 different percentages namely 5, 10, 15, 20 and 25%. The mix design for concrete with Brick Kiln Dust is carried out as per IS 10262: 2009. Mix ratio for M 35 grade trial was 1:2.54:2.1 and w/c ratio taken 0.4. Details of mix proportion for M35 concrete are given Table III.

TABLE III MIX PROPORTION

S. No.	Cement %	BKD %	Water %	F.A %	C.A %
1	100	0	0.4	100	100
2	95	5	0.4	100	100
3	90	10	0.4	100	100
4	85	15	0.4	100	100
6	75	25	0.4	100	100

C. CASTING AND TESTING

Mould of rubber based with size 280 x 160 x 80 mm^3 taken for the preparation of dumbbell shaped sample of paver block. Firstly, the suitable w/c ratio is found by workability test. The material required like cement, water, fine aggregate and coarse aggregate were mixed together as per trial mix proportion and paver blocks were casted. After de-moulding, samples of paver block were kept in under shade for one day and after that samples were cured in water for determining compressive strength in Universal testing machine and calculating water absorption.

III. EXPERIMENTAL PROCEDURES

A. WATER ABSORPTION TEST

Water absorption was done by keeping block samples fully submerged in water. After 7 days blocks were taken out from the water and left for 2 minutes to drain. Visible water is removed from the sample by damping cloth and after that weight of samples are taken and its saturation weight. Then paver blocks are kept in the ventilated oven at 105±7℃ for 24±2 hours and its dry weight is measured.

This procedure of water absorption test was carried out for samples after 14 and 28 days.

The percentage of water absorption is calculated as

$$W_{percentage} = \frac{W_w - W_d}{W_d} \times 100\ \%$$

Where,

Ww = Saturation weight of paver block

W_d = Dry weight of paver block

Water absorption percentage with different partial replacement of cement (average of 3 sample) is given in table IV

TABLE IV WATER ABSORPTION PERCENTAGE

S. No.	No of days	Water absorption percentage with different partial replacement of cement (average of 3 sample)					
		0%	5%	10%	15%	20%	25%
1	7	0.87	2.53	2.74	3.85	3.08	2.58
2	14	1.31	3.2	3.73	4.26	3.62	3.29
3	28	2.37	3.39	4.36	5.52	4.28	4.01

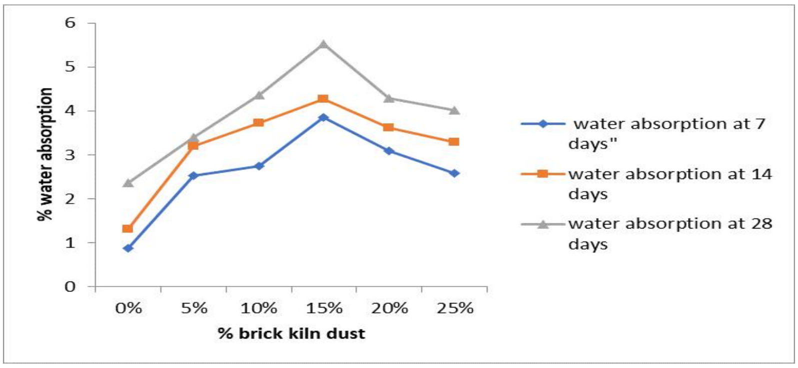

Figure 2 Comparison of water absorption at 7, 14 and 28 days

B. COMPRESSIVE STRENGTH

Compression test is carried out on dumbbell shaped paver block. At each desired curing periods specimens of paver blocks are taken out of water and dried. The blocks were taken for the test. The cubes are tested in Universal testing machine to get the compressive strength of concrete.

The paver block with dimension 200 x 160 x 80 mm3 have the actual surface plane are 28000 mm2. This helped to find out the compressive strength of paver block.

The result of compressive strength of paver block with different partial replacement of cement with BKD (average of 3 sample) in n/mm2 is mentioned in table V.

TABLE V COMPRESSIVE STRENGTH OF PAVER BLOCKS RESULTS

S. No.	No of days	Compressive strength of paver block with different partial replacement of cement with BKD (average of 3 sample) in N/mm^2					
		0%	5%	10%	15%	20%	25%
1	7	31.2	34	36	36.5	32.8	28.4
2	14	35.3	37	38	38.4	33	30
3	28	40.8	40	40	41.7	34.2	31.3

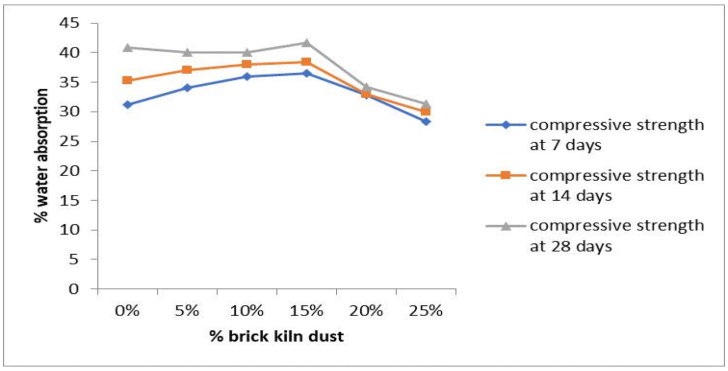

FIGURE 26 COMPARISON OF COMPRESSIVE STRENGTH OF PAVER BLOCK AT 7, 14 AND 28 DAYS

IV. RESULT AND DISCUSSIONS

Water Absorption result

Water absorption test done as per IS 15658: 2000 for 7, 14, and 28 days. Comparison of water absorption at 7,14 and 28 days shown in figure 2 with replacement of cement with brick kiln dust. In table IV water absorption percentage is tabulated for 7, 14 and 28 days. As per figure 2 shown that the water absorption percentage is increasing as the number of days increasing and also varying with replacement of cement with brick kiln dust.

Compressive strength

Figure 3 is showing the comparison of compressive strength of paver blocks at 7, 14 and 28 days with different partial replacement of the cement with brick kiln dust. From the figure graph it can be concluded that the addition of brick kiln dust as partial replacement of the cement with 5 %, 10%, 15 % is reliable to use. So, the paver block can be used in light traffic categories and also some part of medium –traffic categories as results have been found. From the figure 8 it has been also concluded that the compressive strength of paver blocks is increasing from the use of 5 % to 15% and the compressive strength is also decreasing from use of above 15 percent of brick kiln dust in the construction of the paver blocks.

V. CONCLUSIONS

For brick kiln dust concrete paving blocks, the compressive strength of concrete was increased depending upon replacement level. For w/c ratio 0.40, the improvement in compressive strength was observed at replacement level of 15% after this compressive strength of paver block get decreased

The value of water penetration depth as compared to control mix (replacement level 0%) increased gradually for the w/c ratio 0.40 . Maximum water penetration depth was observed as at 15% replacement level of brick kiln dust waste at w/c of 0.40. after this water absorption value decreased

Utilization of brick kiln dust waste will solve the disposal problem associated with this waste material. Also modified concrete paving blocks will reduce the CO2 emission because of less consumption of cement which intern will clean the environment. It may be also noted that the saving in cement will conserve the natural recourses and will reduce the energy demand needed in the production of cement. Hence, Utilization of brick kiln dust waste in concrete paving blocks will produce more sustainable concrete

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